

REMARKS

Claims 26-34 are presently pending in the application.

All of the previous claims have been canceled and the subject matter incorporated into new claims 26-34 as follows. The subject matter from claim 1 has been incorporated into claim 26, from claim 4 into claim 27, from claim 13 into claim 28, from claims 16-17 into claims 29-30, from claims 20-22 into claims 31-33 respectively, and from claim 25 into claims 34. Further, all of the claims now recite a nickel metal-hydride storage battery (previously recited only in dependent claims) having a paste type positive electrode rather than the paste type positive electrode alone. No new matter has been added by these amendments.

At the outset, Applicants note that in the Advisory Action of February 17, 2004, the Examiner has indicated that claims 16-25 are rejected. However, these claims were previously allowed in Paper No. 9. Since the subject matter from claims 16-25 has been incorporated into claims 29-34, Applicants respectfully submit that claims 29-34 are allowable over the prior art of record.

Rejections Under 35 U.S.C. § 103(a) Based on JP '701 and JP '508, Alone or in View of Kato or Ikoma

For the reasons set forth in previous Office Actions, claims 1 and 4 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over JP 11-219701 ("JP '701") in view of JP 08-203508-A ("JP '508"). Further, claim 7 has been rejected under § 103(a) as being unpatentable over JP '701 in view of JP '508, further in view of U.S. Patent No. 6,083,642 of Kato ("Kato"). Claims 10 and 13 have been rejected under § 103(a) as being unpatentable over JP '701 in view of JP '508, further in view of U.S. Patent No. 4,837,119 of Ikoma. The Examiner's bases for rejection and Applicants' arguments, which are relied upon in full, were described in detail in the Request for Reconsideration filed September 17, 2003 and will not be repeated here.

In the Advisory Action dated February 17, 2004, the Examiner argues that the previously proposed amendment to claim 1 to incorporate the features of claim 7 (that the cobalt in the cobalt oxyhydroxide in the first and second active materials has a valence greater than about 3) and the corresponding arguments are not persuasive as follows. First, the Examiner maintains that the application of Kato to the teachings of JP '701 and JP '508 render the teaching of claim 7 obvious since Kato clearly teaches the advantages of using cobalt with an oxidation state greater than 3, and that although the prior art has different motivation to combine, there is motivation nonetheless. The Examiner further argues that the original disclosure does not set forth clear evidence supporting the unexpected results of the combination as recited in claim 1, but appears more particularly drawn to the specifics of the nickel valence limitations. Additionally, the Examiner contends that the Comparative Example, while identified as an example from JP '701, does not provide proper and convincing evidence to overcome the § 103 rejection of JP '701 in view of JP '508. Therefore, the Examiner refused to enter the previously proposed amendments, and still held the claims to be obvious over the prior art rejections of record as previously set forth.

Since all of the rejected claims have been canceled, all of these prior art rejections are rendered moot. Further, Applicants respectfully submit that the rejections are also not relevant to claims 26-28 for the following reasons.

As previously argued, one skilled in the art would not be motivated to apply a negative electrode that improves the charge/discharge cycle life of a nickel-cadmium storage battery to a positive electrode of a nickel metal hydride storage battery or the like. Since the positive and negative electrodes are completely different in potential range during the operation and electrochemical function, the excellent structure employed for a negative electrode cannot be always favorable to the same degree when it is applied to a positive electrode.

In response, the Examiner responded that JP '508 teaches that by selecting the nickel hydroxide valence in an electrode of a rechargeable battery, the charging and discharging characteristics of the battery can be improved. One of ordinary skill in the art would allegedly have found such a teaching to be equally applicable to either positive or negative electrodes in rechargeable batteries which employ nickel as an active material for the purpose of optimizing the charge and discharge characteristics of the electrode. Furthermore, the Examiner contends that given the ranges of nickel hydroxide (90-60 weight %) to nickel oxyhydroxide (10-40 weight %), the nickel in the hydroxide has a charge of +2 and the nickel in the oxyhydroxide has a charge of +3. Given the ranges set forth therein (about 60% from the hydroxide and about 40% from the oxyhydroxide), the Examiner concludes that the average oxidation number of the nickel in the electrode will be above 2.5, and close to or slightly above 2.6, which is within the critical range disclosed in the application.

Applicants again respectfully traverse these arguments as follows. JP '508 discloses that addition of a nickel compound having a nickel valence of 2.2 to 3.4 to a paste-type cadmium negative electrode elongates the cycle life of a nickel-cadmium storage battery. Since a trace amount (0.05 to 1.0 wt%) of the nickel compound, added to the cadmium negative electrode of the nickel-cadmium storage battery, inhibits coagulation of cadmium during the charge/discharge cycles, the above effect is achieved. Further, limiting the valence of the nickel compound to 2.2 to 3.4 allows more effective inhibition of the cadmium coagulation because this nickel compound has a larger surface area than a nickel compound having a valence of 2 (nickel hydroxide). JP '508 thus teaches modification of the negative electrode to inhibit its deterioration. However, there is no teaching or suggestion that these modifications would be applicable to the positive electrode.

On the other hand, JP '701 relates to a modification of a positive electrode to provide a suitable discharge reservoir in a negative electrode of an alkali storage battery. More specifically, JP '701 discloses a positive electrode comprising a first active material and a second active material mixed in a predetermined ratio.

For these reasons, JP '508 and JP '701 are different in purpose, means for accomplishing the purpose, and effect achieved. JP '508 does not include any description of the discharge reservoir and is silent about any modification of the positive electrode. Since JP '508 is directed to the inhibition of cadmium coagulation in the negative electrode and not to the modification of the positive electrode, there would be no motivation to limit the nickel valence of the second active material in the positive electrode to 2.2 to 3.4. Therefore, it would not be obvious for one skilled in the art to combine JP '508 and JP '701.

By this amendment, the claims recite a nickel metal-hydride storage battery, not a nickel-cadmium storage battery as taught in JP '508. A nickel metal-hydride storage battery as claimed does not contain cadmium in both the positive and negative electrodes. Thus, the target of the modification in JP '508 is not included in the present invention.

The favorable effects of the present invention are particularly exhibited in nickel metal-hydride batteries as follows. In both nickel-cadmium storage batteries and nickel metal-hydride batteries, gas is generated in the battery in an overcharged state. However, in the latter, the positive electrode generates oxygen gas, while the negative electrode generates hydrogen gas, both due to electrolysis of water in the electrolyte. The oxygen gas generated in the positive electrode is transferred to the negative electrode and reacts with hydrogen gas to form water. On the other hand, the hydrogen gas generated in the negative electrode is chemically absorbed into the hydrogen absorbing alloy in the negative electrode. The negative electrode contains the hydrogen absorbing alloy in an excess amount with respect to the positive electrode capacity

(called a charge reservoir), so that it can absorb hydrogen even in a fully-charged state. The negative electrode is provided with a discharge reservoir so that the negative electrode can discharge even when the positive electrode is fully discharged.

If the discharge reservoir increases to an excess degree, the charge reservoir will decrease by the excess of the discharge reservoir, even though the total amount of the hydrogen absorbing alloy has not changed. This decrease reduces room for absorbing hydrogen in the overcharged state. As a result, the hydrogen gas generated in the negative electrode in the overcharged state cannot be absorbed at a sufficiently high rate. Therefore, it is essential to limit the discharge reservoir to the minimum required level and the discharge reservoir should be controlled with precision. Furthermore, variations in discharge and charge reservoirs after the battery has been assembled should be avoided as much as possible. In particular, increases in discharge reservoir (decreases in charge reservoir) should preferably be avoided.

On the other hand, a nickel-cadmium storage battery is designed so that no hydrogen gas is generated from the negative electrode in the overcharged state, since the negative electrode of this type of battery cannot chemically absorb hydrogen gas. Accordingly, the capacity of the cadmium negative electrode in the nickel-cadmium storage battery is typically far larger than the positive electrode capacity. For example, the negative electrode is designed to be twice as large in theoretical capacity as the positive electrode to give a sufficient allowance to the charge reservoir.

Therefore, since the capacity of the cadmium negative electrode has a sufficient allowance, even if the discharge reservoir increases to some degree, the influence of this increase is far smaller than in a nickel metal-hydride storage battery. That is, while optimization of the discharge reservoir is especially important for a nickel metal-hydride battery, its effect is extreme. The opposite is true with a nickel-cadmium storage battery.

For all of these reasons, there would be no reason to apply the teachings of JP '508 to JP '701 or to the present invention.

The Examiner has previously acknowledged that JP '701 and JP '508 do not teach that the oxidation number of the cobalt in the oxyhydroxide in the active materials is greater than 3, but argued that Kato discloses a process in which the nickel active material is coated with cobalt having an oxidation number greater than 3, and that using a higher valence cobalt material provides a positive electrode material having high active material utilization and improved overdischarge withstanding characteristics. Therefore, the Examiner concluded that it would have been obvious to one of ordinary skill in the art at the time of the invention to modify the teachings of JP '701 by using a higher valence cobalt material to provide such favorable properties. Applicants respectfully traverse this rejection, to the extent it applies to claim 26, for the reasons set forth previously and for the additional reasons which follow.

The present invention is directed principally to pursuing the reduction of the discharge reservoir of a battery as compared with conventional batteries. Applicants have found that this goal may be achieved preferably by utilizing a combination of cobalt oxyhydroxide having a cobalt valence greater than 3 in the active materials and nickel having an oxidation number of ≥ 2.6 and ≤ 2.92 . Further, the use of such cobalt oxyhydroxide provides several advantages over prior art batteries.

First, if the valence of cobalt is initially less than 3, it may change to 3 during charge/discharge cycles, resulting in the undesirable production of a discharge reservoir while the valence of cobalt is changing to 3 in the battery (see specification page 3, line 22 to page 4, line 4). If Co contained in the positive electrode has a valence of 3 or less, it is oxidized to increase the valence to larger than 3 during the charge. At this time, the discharge reservoir of the negative electrode increases because an oxidation reaction of cobalt consumes part of the

charged power in the positive electrode, while the charging reaction of the negative electrode consumes the entire charged power in the negative electrode.

On the other hand, if cobalt oxyhydroxide with a valence of cobalt greater than 3 is used initially, the valence does not change and the formation of such an excessive discharge reservoir can be eliminated. As previously described, when the Co valence is 3 or less, the positive and negative electrodes will differ in the amount of accepted electric power even if they are given the same amount of electric power. Thereby, the discharge reservoir increases. To avoid this inconvenience, it is effective to set the Co valence higher than 3 in advance. In other words, it is essential to stabilize Co to inhibit a side reaction caused by Co as far as possible. Kato does not teach or suggest that the variations in discharge and charge reservoirs can be inhibited by setting the Co valence higher than 3 in advance. Accordingly, the present invention demonstrates unexpected results which would not be expected based on the proposed combinations of cited references.

Second, since cobalt oxyhydroxide with a cobalt valence greater than 3 is very stable throughout the long cycle of charge/discharge, it is possible to prevent changes of the discharge reservoir resulting from cobalt valence changes, as well as to accurately maintain the discharge reservoir to be an appropriate small amount throughout the long cycle.

Finally, the utilization rate of the second active material can be improved by using cobalt oxyhydroxide with a cobalt valence greater than 3. In order to efficiently obtain the second active material, the first active material is used as the starting material and then subjected to an oxidation treatment to obtain the second active material. If the valence of cobalt in the surface layer of the first active material is 3 or lower, the utilization rate of the second active material will become low compared with the utilization rate of the starting first active material.

This may be because the cobalt with a valence of 3 or lower adversely affects the produced second active material.

In contrast, if the valence of cobalt in the surface layer is greater than 3, for example 3.12 or 3.19, the second active material utilization rate is almost the same as that before the oxidation. The cobalt compound with a cobalt valence greater than 3 has a structure in which alkali metal ions are intercalated between the layers, and is thus more stable than that with a valence of 3 or lower.

In summary, by using cobalt oxyhydroxide with a cobalt valence greater than 3 combined with regulating the mean valence of nickel, according to the present invention, it is possible to:

- (a) eliminate the excessive discharge reservoir due to the valence change of cobalt;
- (b) avoid the variation in the discharge reservoir throughout the long cycle; and
- (c) prevent the second active material utilization rate from decreasing.

Kato teaches coating nickel active material with cobalt having an oxidation number greater than 3 for providing a high active material utilization rate and improved overdischarge withstanding characteristics. However, Kato does not teach or suggest that regulating the valence of cobalt in cobalt oxyhydroxide would additionally stabilize the cobalt oxyhydroxide, which significantly affects and optimizes the discharge reservoir. Accordingly, it would not be expected based on the proposed combination that to apply cobalt oxyhydroxide with a valence of cobalt of greater than 3 to JP '701 and JP '508, combined with regulating the mean valence of nickel contained in the positive electrode as claimed, would (a) eliminate the excessive discharge reservoir due to the valence change of cobalt; (b) avoid the variations in the discharge reservoir; and (c) prevent the second active material utilization rate from decreasing.

Additionally, as previously demonstrated, it would not be expected based on the proposed combination of references that the amount of the discharge reservoir of the negative electrode can be optimized by regulating the mean valence of nickel in the positive electrode. As a result, it is possible to reduce the amount of expensive hydrogen storage alloy to be used, thus enabling the production of a low-cost battery with a high energy density (page 31, lines 6 to 11). For example, a battery with a negative electrode discharge reservoir capacity of not greater than 10% more than the positive electrode discharge reservoir capacity (such as recited in claim 28 and described at page 27, line 17 to page 28, line 16 and in Tables 1 and 2) can be produced. As shown in Tables 1 and 2, the batteries according to the present invention (1, 2, and 3) exhibited favorable properties relative to the comparative examples, which is due in part to the difference in oxidation number of nickel in the positive electrodes. It is noted that Comparative Example 13 is the example from JP '701, which is clearly inferior to the presently claimed electrodes. This demonstrates the superiority of the present invention over the prior art.

For these reasons, even if a *prima facie* case of obviousness had been established by the Examiner based on any of the proposed combinations of references, it would be overcome by all of the unexpected results exhibited by the present invention. Accordingly, reconsideration and withdrawal of the § 103(a) rejections are respectfully requested.

Regarding the rejection based on JP '508, JP '701 and Ikoma, Applicants respectfully submit that it is not applicable to claim 28 as follows. Briefly, while the Examiner previously acknowledged that JP '508 and JP '701 do not teach that the battery further comprises a negative electrode comprising a hydrogen storage alloy, a separator, an aqueous alkaline electrolyte solution, a sealing plate having a safety valve and a battery case as claimed, the Examiner contended that such modifications of the overall components of the battery would have been readily apparent. Further, the Examiner argued that Ikoma discloses a sealed storage

battery comprising a positive electrode, negative electrode, separator, aqueous electrolyte solution, and a sealing plate having a safety valve. Therefore, the Examiner concluded that it would have been obvious to one of ordinary skill in the art at the time of the invention to modify the teachings of JP '701 by providing a negative electrode and electrolyte solution to effectively enable charge transfer from the positive electrode to a second electrode across the electrolytic medium, to use a separator to electrically isolate the positive and negative electrode materials, to provide a sealing plate to the open end of a battery to seal the battery components within the battery and isolate them from the external environment, and to provide a safety valve in the sealing plate to compensate for internal pressure fluxes.

Applicants once again point out that Ikoma teaches a sealed storage battery comprising a positive electrode, a negative electrode, an alkaline electrolyte, a separator, and a sealing plate having a safety valve. However, Applicants claims a nickel metal-hydride storage battery having a paste type positive electrode and a discharge capacity of the negative electrode which is 1 to 1.1 times larger than that of the positive electrode. As previously explained, neither JP '701, JP '508 nor their combination teaches or suggests all of these elements, and Ikoma does not cure these deficiencies.


Accordingly, no *prima facie* case of obviousness has been established based on the proposed combination of JP '701, JP '508 and Ikoma, and reconsideration and withdrawal of the § 103(a) rejection are respectfully requested.

Based on the preceding Amendments and Remarks, it is respectfully submitted that the pending claims are patentable, distinct from the prior art of record, and in condition for allowance. A Notice of Allowance is respectfully requested.

Respectfully submitted,
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March 23, 2004
(Date)

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Encl: RCE, Petition for Extension of Time